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THE CLOSING OF MICHIGAN GLACIAL LAKES.

By B. B. SMYTH, Topeka. Read before Academy January 3, 1896.

Livingston county, Michigan, is near the center of the state; and while its elevation is not great above the lakes, yet it is about the highest land in central Michigan. The waters from it run northward into Lake Huron, westward into Lake Michigan, and southeastward into Lake Erie.

There is very little native rock exposed in the county; there is a heavy mantle of drift nearly all over the county, in many places exceeding 100 feet in depth. This drift varies in its nature in different parts of the county: in some places it consists largely of clay thickly interspersed with rounded pebbles and boulders from four inches to perhaps two feet in diameter; in other places the drift consists largely of gravel and water-worn pebbles to a depth of 20 to 40 feet, and again it consists of sand and clay heaped up into what is known as "short hills," often to a height of more than 100 feet. Moraines of stone are frequent, and nearly always run due east and west, occasionally varying to south of east and north of west.

Those high hills and drift lands are by no means the barren lands one might be led to suppose. Much of the drift is mixed with a large proportion of lime, or limestones, carried from hills not very far remote; and the presence of stones on the surface seems to have a tendency to warm the soil and hasten the growth of crops.

On many farms the stones are so thick on the surface that it is impossible to plow without removing the larger part of the stones to a depth that will permit plowing. These stones, although they entail much labor on the farmer, are a source of wealth after all; they furnish material for all the fences needed, besides houses and other buildings. Allow me to describe one, that of Mr. Riddle, of Osceola township, which is representative of a great many of the wealthier farms of the county, especially of that township.

DRIFT PEBBLES.

Miles of stone fence, four feet high, are to be seen. Some of these fences, especially those running alongside the main road, are built with an eye to artistic beauty. The base consists of a layer of heavy, rounded, gray granitoid stones; then follow a couple of layers of smaller water-worn pebbles of nearly uniform size and about 10 inches in diameter; then a layer of heavy red quartzite about 10 inches in thickness; then again several layers of white rounded pebbles, finally capped with a layer of broad greenstone schist and blue limestone. Barn and other buildings are built of the same kinds of stone.

The house, which is quite a roomy one, is built almost entirely of ovoid pebbles about 5 by 8 inches in diameter and 11 inches in length. These pebbles are very uniform in size and laid up in the cementing material in herring-bone style: First, on a solid foundation of quartzite or granitoid boulders, a horizontal row, nearly on end, slanting upward to the right, next a row slanting upward to the left, and so on alternately, making the pebbles stand in zigzag fashion. An occasional binding layer of larger boulders of a different color is put in, the upper layer being especially heavy. The corners and door and window posts are of larger stones of different color laid flatwise; the lintels are of greenstone trimmed. The house has the appearance of having been quite recently built, but an inquiry disclosed the fact that it had been built 18 years before. The cementing material in which these stones were laid must have been of an exceedingly good quality, and the builders must have perfectly understood the art of laying them up in that unique fashion. Except upon the sills and lintels no mark of tool other than that of trowel upon the mortar was noticeable upon the walls. Indeed these pebbles are so hard as to almost defy any tool to work them into shape.

My object in describing such buildings and fences is not merely to show the thrift of the people, but to show the abundance of the drift material, where selections of so many stones, uniform in size, color, and shape, may be made.

LAKES AND MARSHES.

Nearly everywhere, in the hollows among these drift hills and on the low grounds where the hills do not exist, there are small lakes and numerous marshes. The marshes have the appearance of having at one time been lakes. Sometimes the marshes are mere circular belts of marsh surrounding small lakes that are continually growing smaller and smaller. In a few places the marshes have entirely overgrown the small lakes; and near the middle, where they have not become entirely solid, a pole 20 feet long may be pushed down through the marsh into the underlying lake, which has not yet filled up below; in other places where the lake is not yet closed, the edge of the marsh extends out over the lake quite thinly, and in such a way as to overhang the water, often to a considerable distance. By standing on the ground in one spot, and dancing lightly, the surface all around for some little distance may be made to vibrate; and if one were to continue the dancing or vibratory movement he would sink into the soft black muck entirely out of sight. Cows and horses often sink so they are unable to extricate themselves. They are then said to be "mired."

Not all lakes have marshes surrounding them. Sand-bottomed lakes are not surrounded by marshes, but the water washes the clean hard shore; mud lakes too are seldom surrounded by marshes; but the lakes, whose bottoms are composed of a hard impervious clay, and which have, as nearly all lakes have, small sluggish outlets, are almost invariably surrounded by marsh. Marshes that have grown over shallow lakes have rapidly covered the entire lake and have caused the lake to disappear. The growth of marsh over the edge of deeper lakes, those reaching to a depth of 15 feet and upward, is very slow; and on a lake with a depth of 30 feet the marsh around its edge is scarcely seen to make any progress.

A recent visit to the home of my childhood has shown me what appears to be a surprising reduction in the size of those lakes. Naturally, a 30 years' absence would make the lakes appear very much smaller; but that it is not all a personal difference may be readily seen when the structure of those marshes is taken into account. The tall grass growing on the edge of the marsh next to the water, when it decays, largely overhangs the edge into the water, where it is held in place by the growing rootlets of the grass, until, after the lapse of many years, a perceptible thickness must be added to the extending edge of the marsh. The growth and extension of marsh is more rapid than the wear of the edge by the wash of the waves, which is scarcely anything. Again, the growth of pond-lilies and other water plants in the shallows rapidly hastens the extension of marsh and the closing of the lakes by allowing a slight deposit on their floating leaves, to be followed by an interwoven mass of vegetation which permits the accumulation of vegetable mold and humus. Extension of marsh under such conditions is many times more rapid than where the water is deep. Extension of marsh over a deep lake may be estimated at one thirty-second to one-twelfth of an inch annually. This would equal a growth of one foot horizontally toward the center of the lake in 150 to 400 years. The narrowest marsh I have seen around a little lake 30 feet or upward in depth is about 150 feet in breadth; and if 7,000 years be taken as its probable duration, since the disappearance of the permanent ice, the lowest estimate would be about right. On the other hand, lakes one-half to one mile in extent and not over six feet deep have been entirely overgrown by marsh and are dried up.

The thickness of the black vegetable stratum that covers any marsh varies, according to the depth of the original lake, from 2 to 10 or 12 or even 20 feet, where the lake is very deep. It takes a very long time for a thickness of two feet or more to form by the decay of the grasses.and other marsh plants that grow there. After the marsh becomes firmly fixed to the ground, tamarack trees grow, and it becomes a swamp.

Underneath the overhanging marshy covering at the edge of any lake may be found a certain depth of infusorial or calcareous earth. This forms around the edge of all marsh lakes. It does not keep pace in its growth with the growth of the marsh; and if the edge of the lake where the shells may be found should be moderately deep, the shells are constantly falling through the ooze to the bottom, leaving the upper portion next to the marshy covering very thin and loose; yet the growth of marsh surface continues, and when the lake is not deep its extension toward the center is reasonably rapid.

A Marsh Lake.

A description of one of these lakes in this connection will be appropriate, as it is representative of a large class of very small lakes, all of which come under the rule as to closing: A small deep lake in the edge of the "short hills" and close to the great Shiawassee marsh hereafter described. It is known as Drew's lake, and is nearly surrounded by hills 25 to 40 feet high. The lake is nearly circular; diameter about 400 feet from marsh edge to marsh edge; depth at edge of marsh 15 to 18 feet; depth in middle of lake about 30 feet. The water is quite clear, though slightly reddened as though it were a weak infusion of grass, tamarack, and other leaves. There is no permanent inlet; there is a small sluggish outlet discharging about one-half cubic foot per second. Outlet is bordered by marsh land.

Completely surrounding the lake is an annulus of marsh land 50 to 75 feet wide, covered with marsh grasses and sedges, with a few other marsh plants interspersed. Most of the surface of the marsh is one or two inches above the level of the water; though there are spots one or two inches below the surface of the water. Such spots are covered exclusively with a small species of *Eleocharis* (possibly *E. tenuis*), perhaps several species.

Near the outlet and at one other spot which approximates a temporary inlet, there are boggy tracts in which the grass grows only on the tops of "bogs." These "bogs" are tufts of peat about 8 to 12 inches across and 10 inches high, broadest at the top, and 4 to 10 inches apart. They are level on top and uniform in height, with perpendicular or concave sides. Water flows sluggishly at times in the interstices between the bogs. There is no vegetation between the bogs, except in the drier places a little sphagnum.

The marsh floats. Thickness at its edge about 30 inches; depth of underlying water about 14 feet; one or two feet deeper in high water. Thickness or depth of marsh 50 feet back from the edge, 6 feet; depth of underlying ooze about 8 feet. Measurements were taken with a smooth, sharp-pointed tamarack pole. The relative depths of humus and underlying ooze could only be determined by the difficulty of pushing the pole down. As soon as the peaty stratum was penetrated the pole would go down easily. The pole brought up adhering to its point a few small gastropods and other minute shells. The ooze underlying the peat consists mostly of minute particles of humus, having a specific gravity of 1.016, hence resting but very lightly at the bottom. The shells of dead diatoms, with a small admixture of minute gastropods which at one time lived at the surface of the marsh, having greater specific gravity, fall through to the bottom and form a white stratum several inches in thickness in the course of time. This stratum is removed by the wagon load from dried marshes and spread over lands as a fertilizer for wheat. It is locally called "marl." I do not know its value.

For the first 25 feet surrounding the lake the marsh is a perfect morass, quite dangerous to walk upon, though it may be done; for the next 25 feet it is reasonably safe. It is all unsafe for cattle. This portion of the marsh is sprinkled with the common pitcher plant, *Sarracenia purpurea.*

Immediately surrounding this first annulus is an annulus 10 to 25 feet wide, covered with the same species of marsh grasses and plentifully with *Cassandra calyculata*, *Andromeda polifolia*, and *Kalmia glauca.*

Next outside of this is an annulus about 15 feet wide, covered almost exclusively with small tamarack trees 3 to 15 feet high. Here the marsh rests upon the solid ground.

The next annulus surrounding the lake is covered with full-grown tamarack trees. The width of this ring is 40 to 50 feet, widening to more than double that in a pocket between the hills. This strip, although a few inches higher than the grassy marsh inside, is usually covered with several inches of water, and is known as "swamp." There is a slight admixture of clay with the peat here, being carried from the neighboring hills. The peat here is composed of sphagnum instead of grass, as in the marsh inside. The sphagnum grows plentifully here between the roots and knees of the tamarack trees.

Outside of the tamaracks, next to the hills, there is an interrupted strip of black ash swamp, varying from nothing to 50 or 60 feet in width in the pocket between the hills. Here there are a few red birch trees, with here and there an occasional high-bush cranberry (*Viburnum opulus*) and clump of high-bush huckleberry (*Vaccinium ovalifolium*). In this part of the swamp the wash from the neighboring hills has accumulated somewhat, so that it is almost dry except in freshets. Outside of this there are cultivated fields.

MARL.

I hold in my hand some samples of marl taken from a marsh at the head of the Shiawassee river, in which the lake has entirely disappeared. The marsh is many miles in length; its width at the place observed is nearly half a mile and its depth in the center is about seven feet. Recently a large ditch has been dug lengthwise through the marsh, cutting down to the clay foundation. Lateral ditches have been dug by the people from the side of the marsh to the main ditch. Measurements of the depth in one of these laterals, down to the blue clay substratum, are as follow: Near outside edge of the marsh, thickness of the black muck, 18 inches; underlying white marl, 5 inches; half way between edge of the marsh and the big ditch, thickness of the muck, 34 inches; underlying marl, 10 inches; thickness near the center of the marsh, of the muck, 4½ feet; underlying marl, 32 inches. The muck would probably have been deeper, but that at about the time of disappearance of the lake there was deepened drainage, causing the center of the marsh to settle down into a dishing shape, leaving the outer portion flat, as are all Michigan marshes.

These three samples of marl were taken from the three localities mentioned as having been measured. No. 1, from the edge of the marsh, represents the most ancient period; No. 3, from the middle of the marsh, the most recent.

To sum up: First, all Michigan lakes are disappearing, not by drainage or evaporation altogether, but by being converted into bogs or marshes. Many shallow lakes are already closed in that manner; all others are closing. Second, deposits in those lakes do not succeed each other from the bottom upward, but from the sides centerward. A find resting on the clay four feet below the surface near the edge of a marsh or ancient lake may represent a time vastly anterior to a find similarly situated 20 feet below the surface near the center of the same marsh.

Another closing observation: Additions of growth in a marsh are not made entirely by horizontal deposits of foliage, but largely by perpendicular additions of grass roots throughout the extent of the newly forming marsh and by perpendicular additions of grass leaves overhanging the edge next the lake. Pressure is mostly horizontal and from the center of the lake toward its periphery by the swelling of the ice in the lake in winter. This aids in making the material constantly more compact after being once formed. It aids also in thickening the deposit by reducing the surface dimensions.

THE STRATIGRAPHY OF SHAWNEE COUNTY.

By J. W. BEEDE, Topeka, Kan. Read before the Academy January 4, 1896.

There are good exposures of the Upper Coal Measures, and especially of the highest Carboniferous coal-beds of workable thickness in the state, in Shawnee county. The best sections are the bluffs on the south side of the Kansas river. The first students of this section of Kansas geology were Meek and Hayden in 1858, and Prof. G. C. Swallow in 1865. Prof. O. St. John published the results of his work in 1881 and 1882. Later Prof. Charles S. Prosser and Prof. E. Haworth contributed to the knowledge of the region.

GENERAL DESCRIPTION.

There are about 550 feet of the Upper Coal Measures strata exposed, ranging from about 1,875 to 2,425 feet above the base of the Coal Measures.* The strata are a succession of limestones, shales, and coal. They dip to the west about 10 feet to the mile. There are no faults or folds of any consequence. The highest stratum of coal found in paying quantity in the eastern half of the state traverses the county in a northerly direction, passing through the central part.

The topography is comparatively simple. The Kansas river crosses the county from west to east, with a broad valley situated largely on the north side of the river. North of the river bottom is a rolling prairie, which rises to an elevation of about 1,100 feet A. T. at the north line of the county. A prairie extends from the south bluff of the river to a high divide, which traverses the county a little south of west, being intercepted for a few miles near Pauline. This divide reaches its highest point in the southwest corner of the county, where it is 1,200 feet A. T.† In the southern part of the county lies the broad valley of Wakarusa creek, which is nearly as low as the river bottom itself. Three heavy limestone systems give the more rugged topography to the county.

While we do not enter into the discussion of the subject in this paper, it may

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* See Prof. E. Haworth, Kan. Univ. Quar., Vol. III, No. 4, April, 1895.

† U. S. topographic sheets.